

A NEW CESTODE FROM THE MANEATER AND MACKEREL SHARKS.

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The present paper, which is a contribution from the United States Bureau of Fisheries Laboratory at Woods Hole, Massachusetts, and the Zoological Laboratory of the University of Missouri, Columbia, Missouri, deals with a new parasitic Platyhelminth found in the mackerel shark (*Isurus dekayi*) and the maneater (*Carcharodon carcharias*). It also discusses probable larval stages of the same.

1. DESCRIPTION OF SPECIES.

PHYLLOBOTHRIUM TUMIDUM, new species.

Type.—Cat. No. 7631, U.S.N.M.

Scolex.—Bothria in pairs corresponding with the flat surfaces of the strobile, apparently sessile in preserved specimens, but really attached by very short pedicels, thin and leaf-like when extended, with frilled or crumpled (lacinio-crispate) margins; each provided with a conspicuous auxiliary sucker. Anterior end of scolex prolonged beyond the bothria forming an eminence which is dome-shaped in outline in dorso-ventral, and conical, in marginal view.

The bothria, as usually seen in preserved specimens, are contracted into frilled and puckered folds to such a degree that their real nature is difficult to interpret. A few were killed while still attached to the mucous membrane of their host, and in them the real character of the bothria is fairly well shown. Figures 2 and 3 are sketches of bothria thus prepared. They are seen to be very thin and leaf-like structures. That the bothria are not sessile, although appearing to be so, may be demonstrated in scoleces which have been fixed under pressure. Also, although the bothria are seated dorsoventrally in pairs, they may appear, in front view, under pressure, to be cruciform. In sections the outer portion of the wall is seen to be a dense layer of short muscle fibers lying at right angles to the surface. This layer is of the same essential structure as that of the auxiliary suckers. The

central portion of the bothria is continuous with the parenchymatous tissue of the strobile. The longitudinal muscle fibers of the strobile continue into the bothria, where they radiate to the external dense layer to which they are attached. It is the unequal contraction of these muscle fibers which causes the crumpling and folding of the bothria. A loop of the water-vascular system enters each bothrium where it follows a course in the main parallel with the margin, and distant from the margin about one-fourth the diameter of the bothrium.

Ganglion cells were noted in sections of the scolex in the following situations: In the axial parenchyma and myzorhynchus where they were relatively few and small (fig. 11). Larger cells were noted in the bundles of muscle fibers, in the pedicels, and central portions of the bothria. Others were noted in the dense superficial layer, appearing to be relatively more numerous in the central portions of the bothria; others in the compact tissue of the auxiliary suckers, and in the superficial layer of the back of the bothria. The ganglion cells of the dense tissue, and many of those which are associated with muscle fibers in the parenchyma, are characterized by having large nuclei with conspicuous nucleoli, the cytoplasm much branching and with rather indefinite limits (fig. 12). The cells belonging strictly to the parenchyma, and some of those which are associated with long muscle fibers have definite outlines, which are more or less oval. One of these small oval-elliptical cells measured 0.012 mm. in the longer diameter; near by was another 0.03 mm. in diameter, with a nucleus measuring 0.012 and 0.009 mm. in the two principal diameters. Figures 12, *a* to *f*, are camera lucida stretches of ganglion cells as they appeared in a series of sections of a scolex.

Strobile.—Rather slender, linear and flattened throughout. Segments begin a short distance back of the scolex as crowded transverse lines. The proglottides are at first very much broader than long, ultimately becoming squarish, then longer than broad. Maturing and adult proglottides longer than broad, with bluntly rounded angles. Free proglottides much longer than broad, the anterior end usually more or less rounded or knob-like.

In a specimen mounted in balsam, at a point 3 mm. back of the scolex, where the strobile was 0.6 mm. in breadth, the proglottides were 0.04 mm. in length. This specimen was 12 mm. in length. The last four proglottides averaged 0.42 mm. in length; the breadth was 0.28 mm. The last segment was more slender and longer than the preceding three, which did not differ much in length and breadth. The length of the posterior segment was 0.7 mm.; its breadth was 0.21 mm. at the anterior end, tapering to 0.12 mm. near the posterior end. The last 10 segments of a larger strobile averaged 0.9

mm. in length; the length of the first of the series was 0.77 mm., its breadth 1.19 mm.; length of penultimate segment 1.05 mm., breadth 1.05 mm. Length of last segment 1.82 mm., breadth 0.98 mm. near anterior end, tapering to 0.5 mm., near posterior end. A free, ripe segment, mounted in balsam, has the following dimensions: Length 7 mm.; breadth at anterior end 0.42 mm., at level of genital pore (maximum) 2.10 mm., near posterior end 0.42 mm. Dimensions of a free segment in which ova had not begun to develop: Length 4.5 mm.; breadth near anterior end 0.50 mm., at level of genital pore (maximum) 2.27 mm., near posterior end 0.77 mm.

The musculature of the strobile is weak. Beneath the cuticular layer there is a layer of longitudinal muscles, the fascicles of which are flat and ribbon-like, with the long axis of their section at right angles to the surface. The fibers are very fine. In a transverse section near the scolex the thickness of the muscular layer was about one-ninth the shorter diameter of the section. A diagram of the muscle layer is shown in figure 10. No circular muscles were noted in any of the sections.

The cuticle in sections near the scolex is smooth, but farther back becomes transversely rugose. This condition is best seen in sagittal sections (fig. 13).

Reproductive organs.—The genital pores are on the lateral margins, irregularly alternate, and, in adult segments, situated at about the anterior third.

Male.—The cirrus is long, tapering, and spinose. The cirrus pouch has rather weak walls, and lies on the posterior side of the horizontal portion of the vagina. In adult, but unripe, joints the retracted cirrus lies in several folds in the pouch. Beginning at the genital pore it passes postero-mediad at an angle of about 45 degrees with the lateral margin, then becomes slightly tortuous, and continues antero-mediad as the vas deferens, which forms voluminous folds about the anterior curved portion of the vagina.

The testes are distributed along the mid region of the proglottis, from a point approximately midway between the anterior end and the curve of the vagina, to the anterior border of the ovary, and occupy about one-half the width of the proglottis.

Female.—The vagina opens at the genital pore in front of the cirrus. Its course is at first antero-mediad to near the median line, where it turns abruptly posteriad to follow the median line until near the posterior end of the proglottis, where it joins the germ duct. Near the exterior it is slightly constricted; beyond the constriction it enlarges rather abruptly, then tapers more slowly to the curve, so that the portion which is directed antero-mediad is fusiform. At the curve and along the median line the diameter is reduced and remains nearly uniform. The course along the median line is nearly

straight, or, in some cases, slightly sinuous, until a short distance in front of the ovary, where it forms a close spiral and functions as a seminal receptacle.

The ovary lies near the posterior end of the proglottis, and consists of two fan-shaped divisions, symmetrically placed with reference to the median line. Each half is made up of numerous tubular or long-pyramiform lobules. The two divisions are connected by a common transverse portion at the mid line. The shell gland lies on the mid line behind the transverse connecting portion of the ovary and between the two divisions, and is thus practically surrounded by the ovary. The short germ duct begins with a muscular, funnel-like enlargement (ootype), is soon joined by the sperm duct, and a little later by the single yolk duct. The common duct now enters the shell gland, from which it emerges as the oviduct which passes ventrad and shortly expands into the uterus. The main yolk duct is short and is formed by the meeting of two ducts, one from either side of the proglottis (fig. 7). The vitellaria are distributed mainly along the lateral regions of the proglottis, but also extend more or less mediad so as to overlap the testes. They begin near the anterior end of the proglottis, anterior to the testes, and continue to the posterior end. In mature proglottides, in which eggs have not appeared, the vitellaria are quite dense, glandular organs. In joints in which there are considerable numbers of eggs in the uterus, the vitellaria appear as slender, short, string-like masses of yolk cells. This condition begins at the anterior end of the proglottis and progresses toward the posterior end (fig. 8).

The uterus lies along the median line on the ventral side. Figure 6 shows it in section in a mature proglottis which had not yet begun to form eggs. As the segment ripens the uterus becomes greatly enlarged, somewhat sacculate, and ultimately comes to occupy practically all of the interior of the proglottis. The ova are small, and have thin shells. In all of my mounted material the shells have collapsed, so that the ova have very irregular, and more or less angular, outlines. The diameter is about 0.02 mm.

Eggs are discharged by way of a relatively large, longitudinal opening, which appears by dehiscence, on the ventral side of ripe proglottides.

2. NOTES ON HABITAT, DISTRIBUTION, ETC.

A. ADULT STAGE.

1. CARCHARODON CARCHARIAS.

The type (Cat. No. 7631, U.S.N.M.) was collected on June 20, 1903, by Vinal N. Edwards at Woods Hole, Massachusetts, from the stomach of a man-eater shark. No food notes accompanied the speci-

men, but crystalline lenses and teeth of fish were found in one of the bottles containing material from this host, examples of which had been examined by Mr. Edwards on different dates, all in the same month.

The specimen was much contracted, being coiled in a close spiral at the anterior end. The scolex and neck were of a lighter color than the body, which was yellowish white. The breadth of the scolex was 2.5 mm., of the neck 2 mm.; posterior segments long and narrow with a dark line along the median axis. Length of strobile, estimated, 90 mm.

September 1, 1903. A small maneater shark, 4 feet in length, was examined by me at Woods Hole on this date. The stomach contained fish and squid. About 50 of these cestodes were found, most of them in the spiral valve, but a few, 2 or 3, in the stomach. As most of these strobiles appeared to be immature, and, moreover, were associated with jaws and pens of squid, they were interpreted as having been introduced with squid. Two of the strobiles were longer and stouter than the others, which measured about 30 mm. in length. They all contracted strongly when placed in killing fluid.

June 11, 1906. Five specimens were collected by Mr. Edwards from a maneater shark taken off Nantucket on this date. The stomach was empty. These worms, as preserved specimens, were much contracted, and more or less coiled. One, straightened in glycerin, measured 30 mm.

July 1, 1906. A 6-foot maneater shark, taken in Buzzards Bay near Woods Hole, was examined by me on this date. Lenses of fish were found in the stomach. In the spiral valve were found 20 cestodes of this species, with numerous free proglottides containing eggs. The eggs were small, spherical, with rather weak shells, and were dark colored. Length of strobile about 70 mm. They were rather active and had a tendency to crumple and tie themselves in knots. Ripe proglottides flattened under cover-glass measured 9 mm. in length and 3.5 mm. in breadth. Bothria, more or less expanded, were obtained by dropping formaldehyde on scoleces while they were still attached to the mucous membrane of the intestine.

August 17, 1916. A maneater shark measuring 12 feet 7 inches, taken at Menemsha Bight, was examined on this date. The shark had been dead for at least one day, but the scoleces, three with strobiles and one without, were still quite active. The stomach of the shark was empty, but the contents of the spiral valve were dark colored, suggesting that squid had been recent food. It was noted that the behavior of the bothria was like that of the larval forms often found in squid. The auxiliary suckers were alternately extended and retracted

on stalk-like projections of the bothria. Also the front end of the scolex between the bothria was actively extended into a sharp-pointed cone which retracted to a rounded eminence when at rest. The strobiles measured about 30 mm. in length. Proglottides began about 8 mm. back of the scolex. The maximum diameter of the scolex was about 2 mm. and the length about the same. There were no mature segments.

2. ISURUS DEKAYI.

August 9, 1905. A mackerel shark, examined on this date at Woods Hole, contained lenses of fish in the stomach and a broken spine of *Squalus acanthias* embedded in the stomach wall. Nineteen cestodes, similar to those found in the man eater shark, were found in the spiral valve. These were from 10 to 160 mm. in length, living, although the longest alcoholic specimen is only 65 mm. in length. The first distinct segments were about 20 mm. back of the scolex. The first segments very indistinct, succeeding ones very short, ultimately becoming squarish, then longer than broad. There were no ripe segments. The bothria were leaf-like, very mobile and assuming a great variety of shapes, but contracting into a cauliflower-like structure when placed in alcohol.

August 21, 1905. The spiral valve of a mackerel shark taken at Menemsha Bight, which had been in formaldehyde for a few days, was examined on this date. No note had been made of the stomach contents, but the beak of a squid was found in the spiral valve, along with 21 scoleces, and many fragments of strobiles similar to those collected on the 9th, but with rather larger scoleces.

B. LARVAL STAGE.

Larval cestodes belonging to the genus *Phyllobothrium* are common in the squid of the New England coast, both the northern species, *Ommastrephes illecebrosa*, and the southern species, *Loligo pealii*. There are good reasons for thinking that these represent an immature stage of the species described in this paper.

In 1887 Leidy¹ described larval cestodes from the squid *O. illecebrosa*, under the name *Taenia loliginis*, and again,² under the name *Tetrabothisrium loliginis*. In the latter account he designates the cestode as the scolex of *Tetrabothisrium Rudolphi*, or *Phyllobothrium Van Beneden*.

P. J. van Beneden, in 1870,³ published a description of a cestode, under the name *Phyllobothrium delphini* Ed. van Beneden, of which his son had collected the material in 1868. The worms were found

¹ Proc. Acad. Nat. Sci., Phila., 1887, p. 24.

² Idem, 1890, p. 418.

³ Bull. Acad. Belg., vol. 29, pp. 115-117.

in the subcutaneous fat of a porpoise, where they occurred in large numbers in the form of cysts, yellow in color, and one centimeter in diameter, and which were recognized by the son as representing the larval stage of a *Phyllobothrium*. Van Beneden's figure of the scolex of *P. delphini* bears a very close resemblance to the larval *Phyllobothria* from the squid of the New England coast.

Following is a list, with brief notes, of hosts in which I have found larval *Phyllobothria*, which have usually been recorded in my notes as *Phyllobothrium loliginis*.

1. *Ommastrephes illecebrosus*.⁴

2. *Loligo pealii*.

July 28, 1904; food, small menhaden; 1, and 2 fragments.

July 29, 1904; 2, and 2 fragments.

August 8, 1904; 1; length 20 mm. in sea water, 40 mm. after lying for a short time in fresh water.

August 8, 1906; food, fragments of fish; 1, from stomach; length 20 mm., shrunk to about half this length when placed in alcohol.

July 6, 1912; a few found in stomach, 20 mm., more or less, in length; a smaller larval cestode, *Scolex polymorphus*, also noted.

July 8, 1913; 8, in stomach.

3. *Mustelus canis*.

June 6, 1904; 5 dog-fish examined by Vinal N. Edwards; food, squid, lobster, and sand crabs; 3 larval cestodes found.

July 9, 1904; 1 cestode from stomach; active, varying from 15 to 25 mm. in length; neck pink or flesh color, body ivory white, bothria crumpled on edges, lateral vessels sinuous and plainly showing in the neck; agrees exactly with published descriptions of *Phyllobothrium loliginis*. This specimen was given me by Dr. W. C. Curtis, who reported that he had been finding squid in the stomachs of dog-fish which he had been opening, but had not made any note of the stomach contents of the host from which he had collected this worm.

July 25, 1904; 3 dog-fish examined, 1 larval cestode found.

July 30, 1904; 2 dog-fish examined; food, menhaden; 3 larval cestodes, longest 34 mm.

May 16, 1905; 1 examined; stomach contained squid; 1 larval cestode found.

May 23, 1905; 10 examined; stomachs contained squid, alewife, and crabs; 1 larval cestode found in one of the dog-fish, and 4 in another.

May 31, 1912; 4 examined; 6 larval cestodes found.

The examinations reported under the three dates in May were made by Mr. Vinal N. Edwards. Dog-fish examined by Mr. Edwards

⁴ See Proc. U. S. Nat. Mus., vol. 19, p. 792, pl. 52, figs. 1-9.

on one date in July, four in August, and one in September contained no larval cestodes.

Summary.—*Phyllobothrium loliginis* found in *Mustelus canis* on three dates in May, 14 fish examined, 10 larval cestodes found; on one date in June, 5 fish examined, 3 larval cestodes found; on three dates in July, 7 fish examined, 5 larval cestodes found.

Examinations of *M. canis*, no examples of *P. loliginis* found: On two dates in May, 14 fish examined; five dates in June, 28 fish examined; four dates in July, 6 fish examined; nine dates in August, 1 fish examined; three dates in September, 5 fish examined; two dates in October, 3 fish examined.

Squid were recorded in the food on two dates in May, four in June, and one in October, not including dates on which *P. loliginis* was found.

4. *Squalus acanthias*.

The following collections from the spiny dog-fish, with the exception of those made on July 20, were made by Vinal N. Edwards.

May 10, 1904; 20; stomachs filled with squid, alewife, and crabs; larval cestodes in one, 6 scoleces, longest 24 mm., in formaldehyde.

May 19, 1904; 8; stomachs with squid and herring; 6 larval cestodes from stomach of one.

May 20, 1904; 15; stomachs with squid and herring; 10 larval cestodes, from 7 to 20 mm. in length.

June 6, 1904; 100; stomachs with razor clams, squid and eelgrass; larval cestodes found in 18; 84 scoleces, also a number of fragments without scoleces.

May 29, 1905; 12; stomachs filled with young herring; 1 larval cestode found, length 7 mm.

May 14, 1906; 7; stomachs filled with squid; 5 larval cestodes found, 1 quite immature, with scolex inverted.

September 2, 1907; 26, from Provincetown, Massachusetts; squid in stomachs of most of them, fish in a few; 2 larval cestodes in stomach.

May 11, 1908; 32 larval cestodes in bottle, length 20 mm., more or less.

May 20, 1911; no food notes. One of the bottles contained squid eggs; 7 larval cestodes.

May 22, 1912; 40; stomachs full of squid and "jellyfish" (*Pleurobrachia*); 1 larval cestode.

July 20, 1915; 16; spiral valves only brought to the laboratory. All but three of these were examined by Dr. G. A. MacCallum; crystalline lenses of fish noted; 4 small larval cestodes found in one, maximum length, in alcohol, 4 mm. This material came from Sandwich, Massachusetts.

June 2, 1916; 2 larval cestodes, much contracted; no food notes.

Since these specimens of *Phyllobothrium loliginis* from the spiny dog-fish were all immature, and were, with very few exceptions, in the stomach, where they had evidently been recently introduced with the food, *Squalus acanthias* can not be regarded as a final host of this species.

Summary.—Spiny dog-fish were examined on many occasions when no specimens of *Phyllobothrium loliginis* were found. Thus, summarizing by months, the following examinations of spiny dog-fish were made in which this larval cestode was not found: One date in April, 2 fish examined; seventeen dates in May, 112 fish examined; four dates in June, 6 fish examined; two dates in July, 9 fish examined; 7 dates in August, 1 fish examined; four dates in September, 56 fish examined; seven dates in October, 267 fish examined; eight dates in November, 121 fish examined.

To this may be added a summary by months of examinations of spiny dog-fish when examples of *P. loliginis* were found: Eight dates in May, 114 fish examined, 68 larval cestodes recorded; two dates in June, 101 fish examined, 86 larval cestodes recorded; one date in July, 16 fish examined, 2 cestodes recorded; one date in September, 26 fish examined, 2 larval cestodes recorded.

Squid were recorded in the food on one date in April, six in May, two in July, three in August, two in September, two in October, and one in November, not including dates on which *P. loliginis* was found.

5. *Raja ocellata*.

Practically all of the collections from the winter skate here recorded were made by Vinal N. Edwards.

May 12, 1904; 15; stomachs contained razor clams and crabs; 16 larval cestodes from 2 fish.

May 17, 1904; 1; 6 larval cestodes.

May 17, 1905; 7; stomachs filled with "mollusk and squid"; 4 larval cestodes, length of largest 6.5 mm., breadth 2 mm.

May 10, 1906; 10; stomachs filled with crabs; 2 larval cestodes.

May 14, 1906; 7; stomachs contained squid; 1 larval cestode.

May 11, 1908; 6; 27 larval cestodes, length 16 mm., more or less.

June 3, 1909; 1; 11 larval cestodes.

May 13, 1911; 6; stomachs full of squid; 18 larval cestodes from 2 fish.

May 15, 1914; 35; squid in stomachs; 13 larval cestodes from 9 fish.

May 18, 1914; 10; squid in stomach; 5 larval cestodes, 2 with scoleces invaginated.

June 6, 1914; 2; squid in stomachs; 1 larval cestode.

Summary.—*Phyllobothrium loliginis* was found in *Raja ocellata* on nine dates in May, 97 fish examined, 92 larval cestodes; on two dates in June, 3 fish examined, 12 larval cestodes.

Examinations of *R. ocellata* in which no examples of *P. loliginis* were found: On eleven dates in April, 61 fish examined; thirty dates in May, 203 fish examined; four dates in June, 6 fish examined; two dates in July, 9 fish examined; eight dates in August, 16 fish examined; six dates in September, 138 fish examined; sixteen dates in November, 75 fish examined.

Squid were recorded in the food on one date in April, five in May, two in June, one in August, two in September, seven in October, and one in November, not including dates on which *P. loliginis* was found.

6. *Raja laevis*.

The great majority of the examinations here recorded were made by Vinal N. Edwards.

May 10, 1904; 5; stomachs filled with crabs and razor clams; 25 larval cestodes, longest 20 mm.

May 12, 1904; 1; stomach filled with alewife, crabs and razor clams; 6 larval cestodes.

May 13, 1904; 1; 2 larval cestodes.

May 9, 1914; 2; crabs in stomach; 1 larval cestode, length 20 mm.

Summary.—*Phyllobothrium loliginis* was found in *Raja laevis* on four dates in May, 9 fish examined, 34 cestodes found.

Examinations of *R. laevis* in which no examples of *P. loliginis* were found: April, seven dates, 14 fish examined; May, twenty-three dates, 36 fish examined; June, three dates, 3 fish examined; July, one date, 3 fish examined; August, three dates, 11 fish examined; September, two dates, 3 fish examined; October, twenty dates, 53 fish examined; November, five dates, 9 fish examined.

Squid were recorded in the food on nine dates in May, two in June, one in July, one in September, four in October, and one in November.

7. *Thunnus thynnus*.

June 29, 1915; 1; stomach contained 26 squid (*Loligo pealii*), number estimated from "pens" which ranged in length from 110 to 245 mm., also the vertebrae and ribs of a small fish. Ten specimens of *P. loliginis* found, 9 in the stomach and 1 in the intestine. Some of these allowed to lie in sea water were still active on July 1, and some movement in the scolex and neck was discernable on July 3.

Examinations of *Thunnus thynnus* in which no examples of *P. loliginis* were found: On two dates in June, 2 fish examined; two dates in July, 2 fish examined; two dates in August, 2 fish examined; one date in September, 2 fish examined.

Food recorded: Squid, butterfish, herring, and mackerel; algae and eelgrass reported by Vinal N. Edwards from two small horse mackerel examined in September. Squid recorded on one date in July.

8. *Xyphias gladius*.

July 15, 1904; 4; fish taken on the 14th. Food: Fish and squid. One specimen of *P. loliginis* was found which was somewhat con-

tracted, but measured 10 mm. in length and 3 mm. in breadth, when compressed under the cover-glass. Besides this there were rather numerous very small cestode larvae (*Scolex polymorphus*), from 0.1 to 0.75 mm. in length. There appeared to be the beginning of auxiliary suckers on the bothria of these larvae. Associated with these larvae were others, considerably larger, some of them with necks differentiated from the body, with sinuous lateral vessels, distinct auxiliary suckers. The smaller examples had two red pigment blotches in the neck, length 3 mm.

July 20, 1904; 3; fish, hake and menhaden, in stomach of one fish.

Several examples of *P. loliginis* found; other larval cestodes, smaller, and, if not associated with this species, and allied to it by intermediate forms, would be called *Scolex polymorphus*.

July 28, 1904; 1; fish in stomach. *P. loliginis*; 9, grading into forms ordinarily recorded as *Scolex polymorphus*.

July 7, 1913. Dr. G. A. MacCallum showed me a larval cestode from a swordfish which he was examining on this date. The length of the specimen was 10 mm. The general appearance of the worm, which was still active, was like that of *Phyllobothrium loliginis*. The bothria, however, had rather thicker borders, and the auxiliary suckers were relatively larger and deeper than usual.

Sketches of two of these larval cestodes from the swordfish are shown in figures 14 and 15.

Besides the above, I have records of the examination of swordfish, in which no larval cestodes were found in the stomach or intestine, as follows: On five dates in July, 8 fish examined; food, fish in 6, fish and squid in 2.

9. *Spheroides maculatus*.

Collections made by Vinal N. Edwards.

June 4, 1904; 20; "stomachs contained shell-fish"; 2 larval cestodes found in one fish.

June 6, 1914; 10; squid in stomachs; 5 larval cestodes from 4 fish; length of longest worm 30 mm.

I have records of examinations of puffers in which no examples of *P. loliginis* were found as follows: On six dates in May, 81 fish examined; fourteen dates in June, 123 fish examined; ten dates in July, 23 fish examined; seven dates in August, 112 fish examined; six dates in September, 8 fish examined. All the collections made in May and June and a part of those made in the other months were made by Vinal N. Edwards.

Squid were recorded in the food on three dates in June.

10. *Hemitripteris americanus*.

May 31, 1907; 1; 8 larval cestodes.

May 26, 1917; 1; squid in stomach; 3 larval cestodes, 7 to 32 mm. in length.

Sea-ravens, in which no examples of *P. loliginis* were found, were examined as follows: On three dates in January, 9 fish examined; one date in February, 5 fish examined; three dates in April, 5 fish examined; six dates in May, 6 fish examined; four dates in June, 4 fish examined; one date in July, 1 fish examined; five dates in October, 7 fish examined; five dates in November, 10 fish examined; three dates in December, 7 fish examined.

Practically all of the examinations of this host were made by Vinal N. Edwards.*

Squid recorded in the food on two dates in May.

11. *Lopholatilus chamaeleonticeps*.

July 29, 1899; 2 larval cestodes, from intestine.⁵

12. *Merluccius bilinearis*.

July 11, 1900; 3 larval cestodes.⁶

July 2, 1910; 12; squid in stomachs; 1 larval cestode. This specimen was very active. When first seen the scolex and a part of the neck were invaginated; later they were everted. It was still active after it had been lying in sea water for three hours. The neck was a translucent light brown, or tan color, the scolex and body white. The bothria attached themselves to other parasites in the dish and to the bottom of the dish. The neck was very contractile, changing quickly from a thin, linear shape to a thick, crumpled mass. The body, also, was very active, much of the time being elongate, tapering and whip-like.

Whiting were examined, in most cases by Vinal N. Edwards, without finding *P. loliginis*, as follows: On seven dates in May, 34 fish; two dates in June, 3 fish; three dates in July, 16 fish; eight dates in August, 52 fish; two dates in September, 2 fish; nineteen dates in October, 132 fish; thirty-eight dates in November, 331 fish.

Squid were recorded in the food on three dates in May, one in June, one in July, three in August, five in October, and three in November.

13. *Pollachias virens*.

July 1, 1912; 18; food, squid; a few larval cestodes, evidently introduced with the food.

June 9, 1913; 6; stomachs full of squid; 9 larval cestodes.

Other examinations of pollock, for the most part made by Vinal N. Edwards, in which *P. loliginis* was not found: On one date in March, 4 fish; eleven dates in April, 29 fish; twelve dates in May, 44 fish; eight dates in June, 63 fish; two dates in July, 2 fish; four dates in August, 13 fish; seven dates in September, 7 fish; twenty-eight dates in October, 54 fish; eight dates in November, 21 fish; one date in December, 1 fish.

* Bull. U. S. Fish Comm. for 1899, p. 471, pl. 20, figs. 233-234.

* Idem, p. 474, pl. 20, figs. 231-232.

Squid were recorded in the food on one date in May, four in June, one in October.

14. *Phycis tenuis*.

June 7, 1907; 2; squid in stomachs; 85 larval cestodes, in stomach, evidently introduced with squid.

June 5, 1914; 1; squid in stomach; 4 larval cestodes in stomach.

June 15, 1916; 2; squid in stomach; 4 larval cestodes, in stomach.

Following is a summary of examinations of this host, all of which, with the exception of those in the month of August, were made by Vinal N. Edwards. *P. loliginis* was not found on any of these dates, although squid is recorded in the food of practically all of those examined in May and June and on one date in October and one in November.

Summary.—On eight dates in May, 10 fish examined; one date in June, 1 fish examined; four dates in August, 12 fish examined; one date in September, 1 fish examined; sixteen dates in October, 44 fish examined; eighteen dates in November, 88 fish examined; three dates in December. 5 fish examined.

15. *Phycis chuss*.

May 17, 1904; 6; stomachs filled with squid; 1 larval cestode. length 10 mm.

May 14, 1905; 5; stomachs filled with squid; 1 larval cestode.

June 13, 1907; number of fish examined not stated; stomachs filled with herring; 62 larval cestodes.

May 2, 1913; 2; stomachs filled with sand-eels and crabs; 8 larval cestodes.

May 23, 1914; 20; squid in stomach; 9 larval cestodes.

May 25, 1914; 15; squid in stomach; 5 larval cestodes.

May 15, 1914; 30; squid and *Nereis* in stomachs; 9 larval cestodes.

June 5, 1914; 10; squid in stomachs; 60 larval cestodes.

May 15, 1915; 8; herring in stomachs; 5 larval cestodes.

June 5, 1914; 10; squid in stomachs; 60 larval cestodes.

The examinations of this host were nearly all made by Vinal N. Edwards.

Summary.—Following is a summary of examinations when no examples of *P. loliginis* were found: On eleven dates in May, 77 fish examined; four dates in August, 16 fish examined; seven dates in September, 33 fish examined; forty-seven dates in October, 335 fish examined; forty dates in November, 478 fish examined.

Squid were recorded in the food on five dates in May, two in August, two in September, ten in October, and three in November, not including dates on which *P. loliginis* was found.

16. *Paralichthys dentatus*.

May 26, 1904; 1; menhaden and razor clams in stomach; 13 larval cestodes in stomach, from 5 to 16.5 mm. in length, breadth of scolex 1.5 to 2 mm.

May 27, 1904; 1; stomach filled with menhaden; 21 larval cestodes, from 5 to 16 mm. in length.

May 24, 1910; stomach filled with alewife; 8 larval cestodes.

Examinations of this host, except on dates in July and August, were made by Vinal N. Edwards.

Summary.—Following is a summary of examinations when *P. loliginis* was not found: On two dates in June, 2 fish examined; seven dates in July, 10 fish examined; twenty dates in August, 57 fish examined; nine dates in September, 10 fish examined; fifteen dates in October, 20 fish examined; three dates in November, 3 fish examined.

Squid were recorded in the food on one date in July, five in August, two in September, and two in October.

17. *Paralichthys oblongus*.

May 31, 1907; 8; young herring in stomachs; 1 larval cestode.

Summary.—The other examinations, most of them by Vinal N. Edwards, of *P. oblongus*, in which no examples of *P. loliginis* were found, were as follows: On seven dates in May, 12 fish examined; ten dates in June, 36 fish examined; three dates in August, 6 fish examined; one date in September, 1 fish examined.

Squid were recorded in the food on one date in May, two in June, and one in August.

18. *Lophius piscatorius*.

May 31, 1913; 1; tautog and squid in stomach; 2 larval cestodes.

Summary.—Examinations of goose fish in which *P. loliginis* was not found were as follows: On one date in January, 1 fish; one date in April, 1 fish; eight dates in May, 34 fish; six dates in June, 8 fish; nine dates in July, 17 fish; six dates in August, 7 fish; five dates in September, 5 fish; nine dates in October, 13 fish; thirteen dates in November, 15 fish; four dates in December, 6 fish.

Squid were recorded in the food on one date in May, two in June, and one in August.

19. *Leptocephalus conger*.

May 14, 1914; 1; squid in stomach; two larval cestodes.

Conger eels were examined, most of them by Vinal N. Edwards, without finding squid as food or *P. loliginis* as a parasite, as follows: On one date in May, 6 fish; two dates in July, 3 fish; two dates in August, 2 fish; eight dates in September, 50 fish; four dates in October, 37 fish; one date in November, 1 fish.

Selachians in which the larval form, *Phyllobothrium loliginis*, was found were *Mustelus canis*, on three dates in May, one in June, and one in July; *Squalus acanthias*, on eight dates in May, two in June, one in July, and one in September; *Raja laevis*, on four dates in May; *Raja ocellata*, on nine dates in May and two in June. In no case had proglottides begun to develop. If either of these four

species of selachians ever serves as the final host of this cestode the fact is not indicated by any of the data at hand. On the contrary, sufficient numbers of these hosts were examined in the months of July, August, September, October, and November without finding any adult cestode that could be linked up with this form to make it appear very improbable that *P. loliginis* can reach the adult stage in any one of these four selachians.

There is no reason whatever for thinking that *P. loliginis* ever attains maturity in any teliost. It seems, however, that this larval cestode can resist the digestive juices of a great variety of hosts for some time. Hence it doubtless often happens that, before this larval *Phyllobothrium* has reached a true final host, such, for example, as the mackerel shark, or maneater shark, it has sojourned for a shorter or longer time in the alimentary canal of one or more species of selachian, teliost, or squid. It will be noted that *P. loliginis* has been found in two species of squid on four dates in July and three in August; in four species of selachians on twenty-four dates in May, five in June, four in July, and one in September; in thirteen species of teliosts on fifteen dates in May, ten in June, and nine in July.

In my notes on the examination of fishes of the Woods Hole region I find records of squid as food in 45 species of fish in which *P. loliginis* was not found. In 10 of these species examinations were made in May, on seventeen dates; 4 species were examined in June, on six dates; 6 species were examined in July, on seven dates; 18 species were examined in August, on thirty-one dates; 19 species were examined in September, on thirty-five dates; 11 species were examined in October, on nineteen dates; 2 species were examined in November, on two dates.

The adult cestode which is described in this paper was found in but two hosts, *Carcharodon carcharias*, and *Isurus dekayi*, both belonging to the family Lamnidae, or mackerel sharks.

Evidence which points to *Phyllobothrium tumidum* as the probable adult stage of *P. loliginis* is based on the similarity in form and details of structure of the scolex. In making this comparison the terminal sucker of *P. loliginis* is interpreted to be an evanescent, larval structure, as in *Scolex polymorphus*.

The feature which presents the greatest difficulty is that part of the scolex which is posterior to the bothria. In *P. loliginis* there is a rather conspicuous neck portion which is sharply marked off from the strobile proper. In *P. tumidulum* the strobile appears to begin close to the bothria, although segments do not make their appearance at once. In the structure of the bothria and auxiliary suckers, and in the axial portion of the scolex, there is close agreement.

EXPLANATION OF PLATES.

<i>ci</i> , cirrus.	<i>sd</i> , sperm duct.
<i>cp</i> , cirrus-pouch.	<i>sg</i> , shell gland.
<i>ed</i> , dorsal excretory vessel.	<i>t</i> , testes.
<i>ev</i> , ventral excretory vessel.	<i>u</i> , uterus.
<i>ga</i> , genital aperture.	<i>v</i> , vagina.
<i>gd</i> , germ duct.	<i>vd</i> , vas deferens.
<i>lm</i> , longitudinal muscle.	<i>vg</i> , vitelline gland.
<i>n</i> , nerve.	<i>yd</i> , vitelline duct.
<i>o</i> , ovary (germarium).	

Figures 1, 2, 4, 5, 7, 8, 11, 12, *Phyllobothrium tumidum* new species, from *Carcharodon carcharias*; figures 3, 6, 10, and 13 of the same, from *Isurus deKayi*.

PLATE 1.

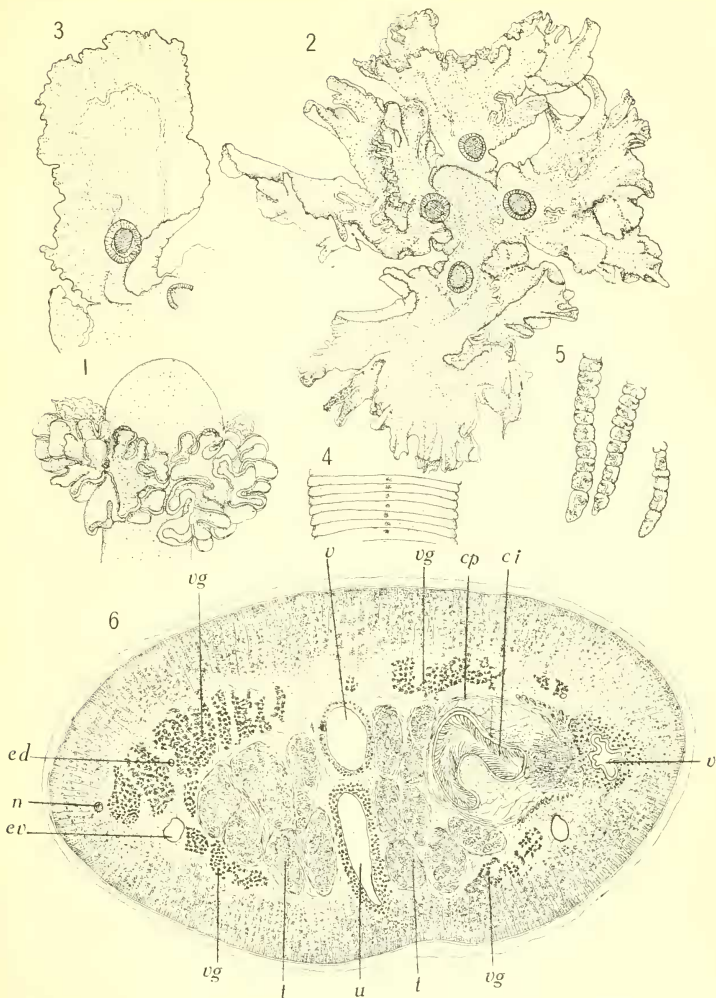
- FIG. 1. Scolex; dorso-ventral view; drawn from an alcoholic specimen. Actual diameter 2.1 mm.
2. Front view of scolex mounted in balsam; partly diagrammatic, folds, which partly covered the auxiliary suckers, having been omitted; greatest diameter 4.6 mm.
3. Single bothrium of scolex fixed while attached to mucous membrane of host, mounted in balsam; diameter of auxiliary sucker 0.35 mm.
4. Proglottides, 15 mm. from scolex; balsam; breadth 1.5 mm.
5. Posterior ends of three strobiles; balsam; length of longest 9 mm.
6. Transverse section of mature, but unripe, proglottis, a little in front of the genital aperture; greatest diameter 1 mm.

PLATE 2.

- FIG. 7. Free proglottis, mature but unripe; balsam; length 5 mm. Sketch by George T. Kline.
8. Free, ripe proglottis; balsam; length 7.5 mm.
9. Diagram showing relation of ducts of reproductive organs in vicinity of the shell gland of *Phyllobothrium tumidum* new species.
10. Detail of longitudinal muscles in cross section, figure 6.

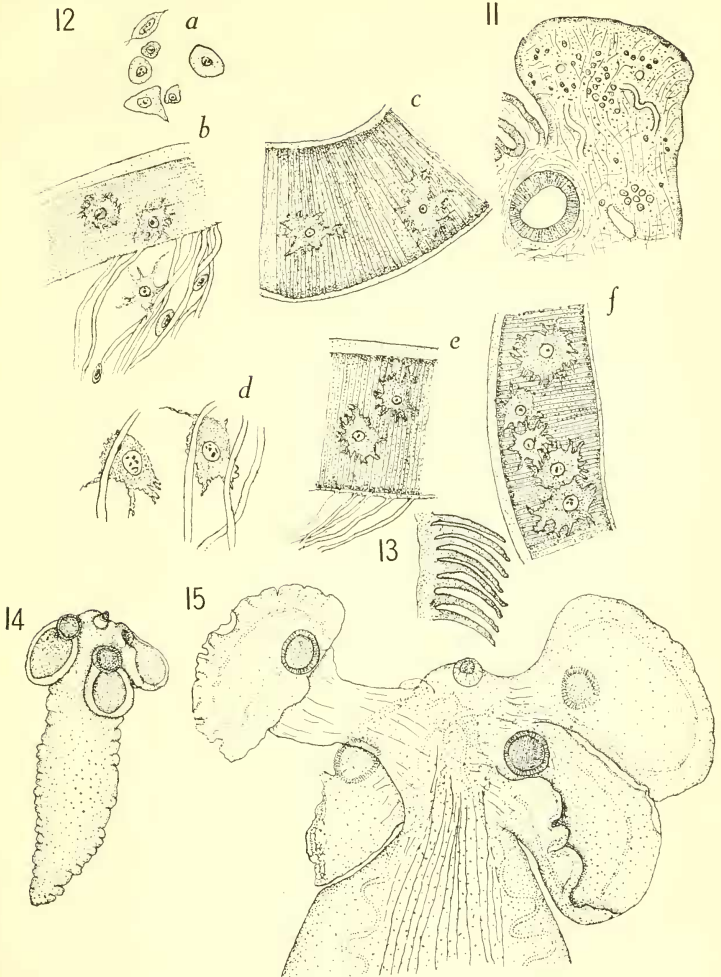
PLATE 3.

- FIG. 11. Sagittal section, somewhat slanting, of anterior end of scolex, showing ganglion cells and excretory vessels; diameter of auxiliary sucker 0.25 mm.
12. Ganglion cells in sections of scolex. *a*, cells in parenchyma; *b*, black of bothrium, and cells associated with muscle fibers; *c*, wall of auxiliary sucker; *d*, cells and muscle fibers at base of pedicel; *e*, marginal region of bothrium; *f*, central region of bothrium; camera lucida drawings with Spencer No. 6 ocular, and 0.4 mm. objective.
13. Sagittal section of cuticle; see text.
14. Larval *Phyllobothrium* from swordfish; balsam; length 1.54 mm.
15. Larval *Phyllobothrium* from swordfish; much flattened at time of fixing; balsam; breadth of neck at base of scolex 0.75 mm.



A NEW CESTODE, PHYLLOBOTHRIUM TUMIDUM.

FOR EXPLANATION OF PLATE SEE PAGE 16.



A NEW CESTODE, PHYLLOBOTHRIUM TUMIDUM.

FOR EXPLANATION OF PLATE SEE PAGE 16.